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Effectiveness of S/S treatment process on leaching behavior of multi-metal bearing sludge

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ABSTRACT

Research investigated Disposal of waste containing heavy metals (Fe, Mn, Cu, Zn, Cr) can causes serious environmental and ecological problems. A large number of wastes can be disposed of by landfilling. Sludge was solidified using OPC, lime and back cotton soil. Concentrations of the metals in the leachate of cube having optimum cement, solid waste combination after 1, 7, 15 days curing are also shown. Compressive strength measurements could be used to determine the performance of the S/S process for this sludge. Compressive strengths of molds show that the higher the sludge/cement ratio, the lower the compressive strength. 50-75% of sludge replacement gives adequate strength for the landfill disposal. The effectiveness of solidification and stabilization again on 15 day leaching test S3, S4 & M3 M4 are the combinations with effective S/S in comparisons to others.

KEYWORDS

Recycling;
Plastics;
Economic analysis;
Waste collection;
High density polyethylene;
Beverage containers.

INTRODUCTION

Solidification/stabilization (S/S) is a treatment technology used to reduce the hazard characters of hazardous waste by converting the contaminants into their least soluble, mobile or toxic form with the addition of a binding material. S/S process has become widely used technology as the treatment of industrial hazardous waste before disposal[3,8]. S/S improves waste handling and physical characteristics, minimizes the surface area across which pollutants can transfer or leach, or limit the solubility[2].

Stabilization/solidification refers to reducing the hazardous behavior, generating a monolithic solid of a waste by means of chemical reactions and high structural integrity (S/S). When a specific waste is stabilized by means of a specific binding matrix, a study is necessary to assess its potential to be used as building materials and therefore the reuse of the waste instead of safe disposal[3].

Portland cement, sometimes on its own or in combination with other treatment agents, is a popular S/S treatment agent due to its low cost, applicability to a wide variety of waste products and its relative ease of implementation. Performance of S/S systems is assessed traditionally using three parameters.

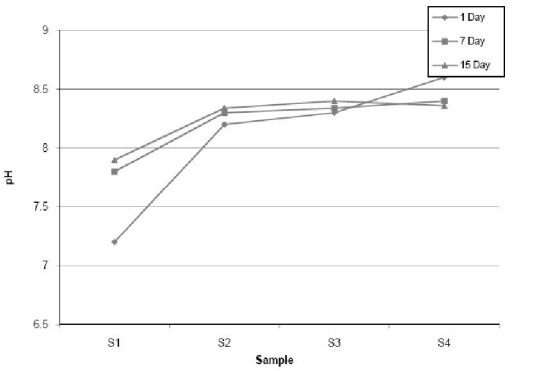

Figure 1 : pH variation in samples in days (Batch I)

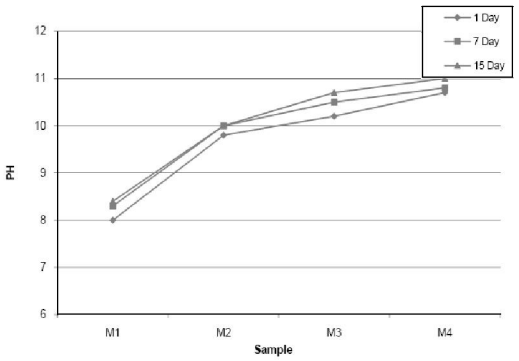

Figure 2 : pH variation in samples in days (Batch II)

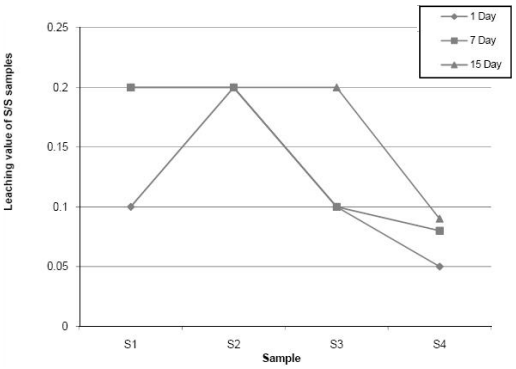

Figure 3 : Leaching variation in samples with pH (Batch I)

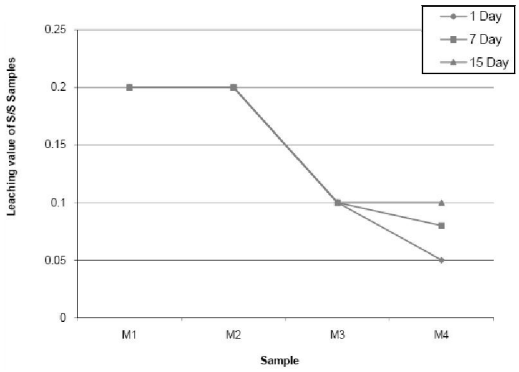

Figure 4 : Leaching variation in samples with pH (Batch II)

Main objectives of this study were implementing the S/S technology on pickling sludge and investigating compatibility with disposal and reuse. Stabilization of hazardous characteristics of the sludge was learned from leaching tests (NEN 7345) after each S/S process.

Sludge/cement ratios and performance of the S/S were determined according to compressive strength of the solidified materials to propose management alternatives for the waste. It was observed that hazardous compounds in the hazardous sludge were stabilized by S/S.

Landfilling

Now a days a large quantity of wastes are disposed at specific land sites which are regulated by the USEPA or state regulatory agencies, place that are designated for the burial of hazardous wastes are called secure landfills. The guidelines for landfill are quite stiff. The site must be located higher than 100 years flood plan and away from the fault zones impermeable lines must be pumped out and treated. Monitoring wells are required to check the quality of ground waters in that area. A large number of wastes can be disposed of by landfilling.

Waste material

During experimental studies, S/S technology was applied on sludge, which was originated from a pickling industry. The metals of concern were iron, and manganese because both metals are present in high amount in pickling sludge. Sludge was solidified using OPC, lime and black cotton soil. For the stabilization of heavy metals, Portland cement and lime used as binding agent

mixed with waste in different ratio. The characteristics of the waste are given in the TABLE 1[12]. Most of heavy metals stabilized in the cement matrix. Physicochemical characteristics of raw sludge are given in TABLE 1. In order to measured the total amount of metal and amount of soluble metals, atomic absorption spectrophotometer (AAS) was used.

METHOD AND MATERIAL

The research work carried out in two stages. The first stage is the preparation of the mold with sludge in different ratio and curing. The second stage is the determination of the leaching characteristics of the solidi-

TABLE 1 : Physicochemical characteristics of raw sludge

S.No.	Parameters	Value
1	pH	7.3
2	TDS (mg/l)	24
3	Dry density (gm/cm^3) %	1.1
4	Specific gravity %	1.2
5	Porosity %	28
6	Water holding capacity %	32
7	Moisture content (dry basis) %	8
	Heavy Metal (mg/gm)	
8	Fe	530
9	Cu	4
10	Mn	72
11	Zn	10
12	Cr	0.1

fied/stabilized samples. Fe & Mn was below detectable limit in cement, lime, and black cotton soil. Size of the mold is 14×6×4cm. Total weight of mold is maintained at 1 kg. The molds were kept in ambient condition for one day curing. Sludge/binder ratio presents in TABLE 2, 3. Strength test were performed with the help of universal testing machine (UTM).

Curing days

Curing period depends on such conditions as temperature, cement type, mix proportions, and so forth. Bridge decks and other slabs exposed to weather and chemical attack usually require longer curing periods. Concentrations of the metals in the leachate of mold having optimum cement, solid waste combination after 1, 7, 15 days curing are also shown. Black cotton soil mixed samples was soiled during the curing period of 7 days. 7 days wet curing was found to virtually eliminate the adverse effect of steam curing on mold strength[5]. 15 days curing is also sufficient for stabilization of heavy metals present in the waste. With sludge replacement above 75%, samples fail to meet the adequate strength of 15 days curing age.

Leaching Test

The effectiveness of S/S in terms of the reduction of contaminant mobility is evaluated through leaching tests NEN 7345[5]. Concentrations of various heavy metals initially present in the hazardous solid waste TABLE 1. Lead solubility increase with pH[6]. Leach-

TABLE 2 : Waste/Binder ratio in percentage (Batch I)

S.No.	Sample	Sludge	Cement	Strength (MPa)
1.	S1	80%	20%	1.8
2.	S2	75%	25%	2.5
3.	S3	66%	34%	3.2
4.	S4	50%	50%	5.25

TABLE 3 : Waste/Binder ratio in percentage (Batch II)

S.No.	Sample	Sludge	Lime	Strength (MPa)
1	M1	80%	20%	1.5
2	M2	75%	25%	2.1
3	M3	66%	34%	3
4	M4	50%	50%	4.5

ing of metals (manganese and zinc) decreases with increase in the pH of TCLP extract upto pH 6, after that it increases with increase in the pH[10]. pH increases in all batches with time. All samples reached to alkaline pH near about 12 (Figure 1,2,3,4). The release of highly soluble species Na, K, Cl, the release of sparingly soluble species such as heavy metals is largely dependent on the equilibrium activity as a function of solution pH[1]. Optimum pH for the stabilization of the metals is in between pH 8.5 to 10.2. Lime dosing increases the pH of the sludge generated from effluent treatment plant (ETP). High pH helps in the stabilization of heavy metals. Leaching of samples Decreases with the increases in pH (Figure 5, 6, 7, 8). The leaching of 15 days cured samples shows complete stabilization of iron and manganese rather then other metals. As the curing time was increased the leaching rate of heavy metals from the solidified matrix reduces[9,11].

RESULTS AND DISCUSSION

Leaching and strength of mold is considered for the landfill disposal of the sludge. The samples S3, S4 and M3, M4 can be used for S/S purpose. The similar results are obtained when the calculation are done for the effectiveness of solidification and stabilization again on 15 day leaching test S3, S4 & M3 M4 are the samples with effective S/S in comparisons to others (Figure 1, 2, 3, 4).

The S/S mass were kept for the leaching purposes. The results of manganese leaching for 1 day, 7 day, and

15 day were found below detectable limit (BDL). On the basis of above, Mn is fully stabilized. The best obtained were with the samples S4 & M4, which contain 20% by weight cement & by 20% lime. In all the % of binder increases mobility of Fe in the mass decreases. The Fe is less in all the combination so the lowest combinations can be applied for the stabilization and solidification process in any of the above.

CONCLUSIONS

This study demonstrated the stabilization of the hazardous compounds of the pickling sludge by S/S technology and keeps to solve problems on the management alternatives of these hazardous wastes. The partial replacement of cement with pickling sludge was proved to be applicable in this study. Nevertheless, when ash replacement percentage is larger than 75%, there is a dramatic loss in UCS regardless of curing age. Composition of sample S3, M3 proved optimum stabilization.

Specific conclusions were:

- Waste in sludge form a pickling industry was determined to be hazardous waste according to the hazard criteria of the hazardous waste.
- Compressive strength measurements could be used to determine the performance of the S/S process for this sludge. In order to prepare molds, sludge was added instead of cement. Compressive strengths of molds show that the higher the sludge/cement ratio, the lower the compressive strength. It was assumed that 90 days cured molds could be potentially used as filling materials.
- When the leaching concentrations were examined according to the sludge/cement ratios, sometimes higher or lower concentrations than the expected values were observed. But these changes could be neglected, since the leaching levels were much lesser than the standards, and the particulate sizes in the mold show differences. For this reason, keeping the particulate size constant in future studies is of great importance.

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